

# Architecting Software the SEI Way

## Essential Steps Toward Mastery

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### Analyzing and Evaluating Enterprise Architectures

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# Outline

## Essential problems for architects -

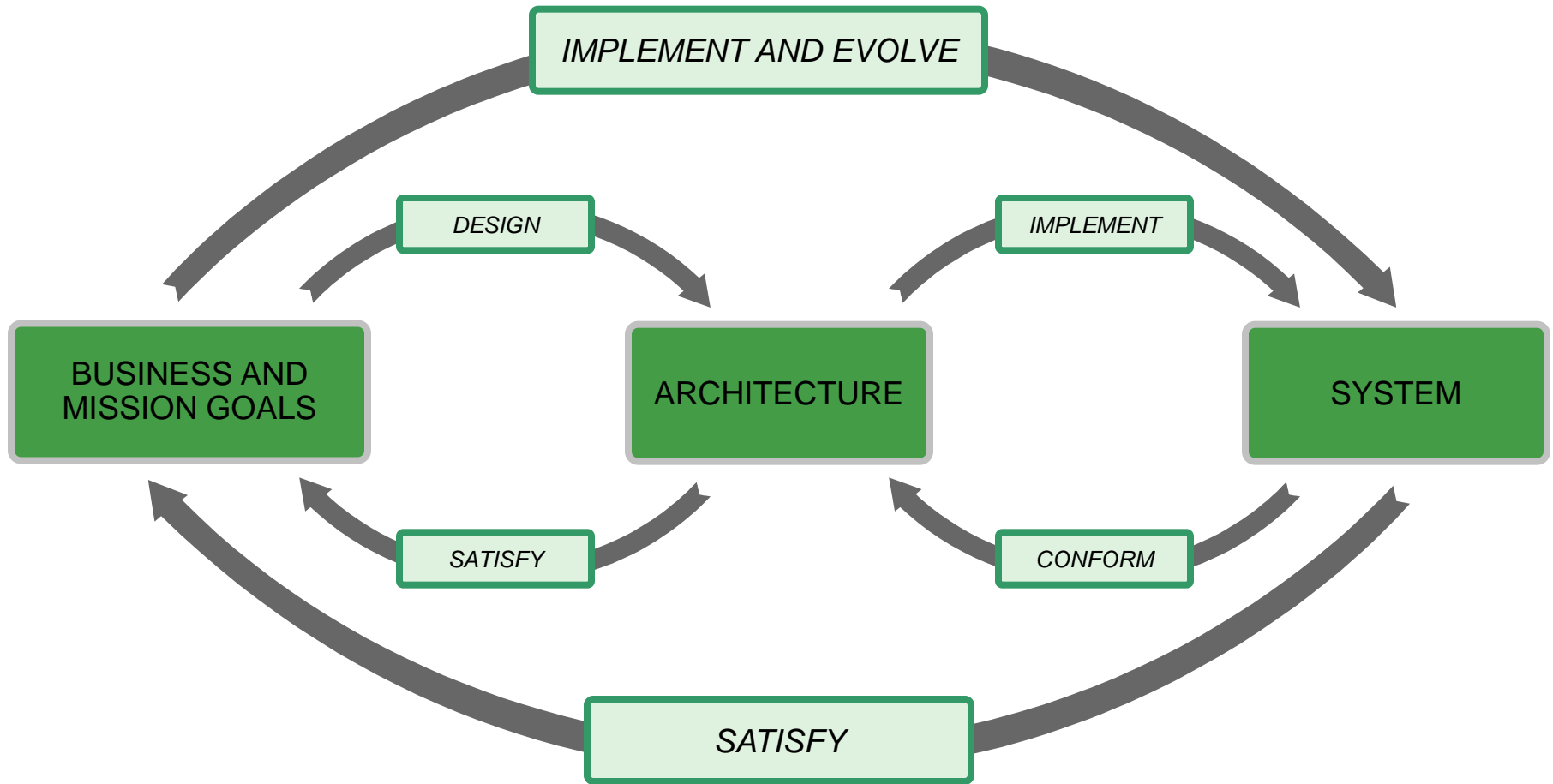
- How do we efficiently translate business goals into quality attribute requirements?
- How do we ensure that these quality attribute requirements are reflected in the tradeoffs and decisions that shaped the architecture?

## Agenda

- Review of the SEI perspective on architecture-centric engineering
- Scaling from software context to systems of systems and enterprise architectures
- An approach to developing quality attribute requirements for enterprise architectures
- An approach to first-pass evaluation of enterprise architectures
- Tying together EA and system/software analysis and evaluation



# Architecture-centric Engineering – Software and Systems



# Principles of Architecture-Centric Engineering

Every system has an architecture, regardless of scale.

Architecture is the appropriate abstraction for reasoning about business or mission goal satisfaction.

Quality attributes have a dominant influence on a system's architecture.

Value derived from business and mission goals governs quality attribute tradeoffs.

Well-founded cost-effective measurements and analyses are the bases for acquiring confidence about system properties.

Architectural prescriptions must be demonstrably satisfied by the implementation.

Today's architectural decisions must appropriately reflect the drivers of system change.



# Quality Attributes Shape Architectures

Quality attributes are properties of work products or goods by which stakeholders judge their quality.

Some examples of quality attributes by which stakeholders judge the quality of software systems are

- performance
- security
- modifiability
- reliability
- usability
- calibrateability
- availability
- social-ability
- throughput
- configurability
- subsetability
- reusability



# What about Functional Requirements?

Functional requirements define the work that the system is intended to do

- Functionality often has associated quality attribute requirements (e.g., a function is required to have a certain level of availability, reliability, and performance).
- We can achieve functional requirements and yet fail to meet their associated quality attribute requirements.
- Functionality can be achieved using many different architectures.
- Achieving quality attribute requirements can only be achieved through judicious choice of architectures.



# Quality Attribute Scenarios for Systems and Software

**“When you say the system should have ‘good performance’, what do you mean? Could you give me an example?”**

One way to describe quality attribute concerns is to use quality attribute scenarios to clearly characterize them.

A quality attribute scenario is a short description of how a system is required to respond to some stimulus.

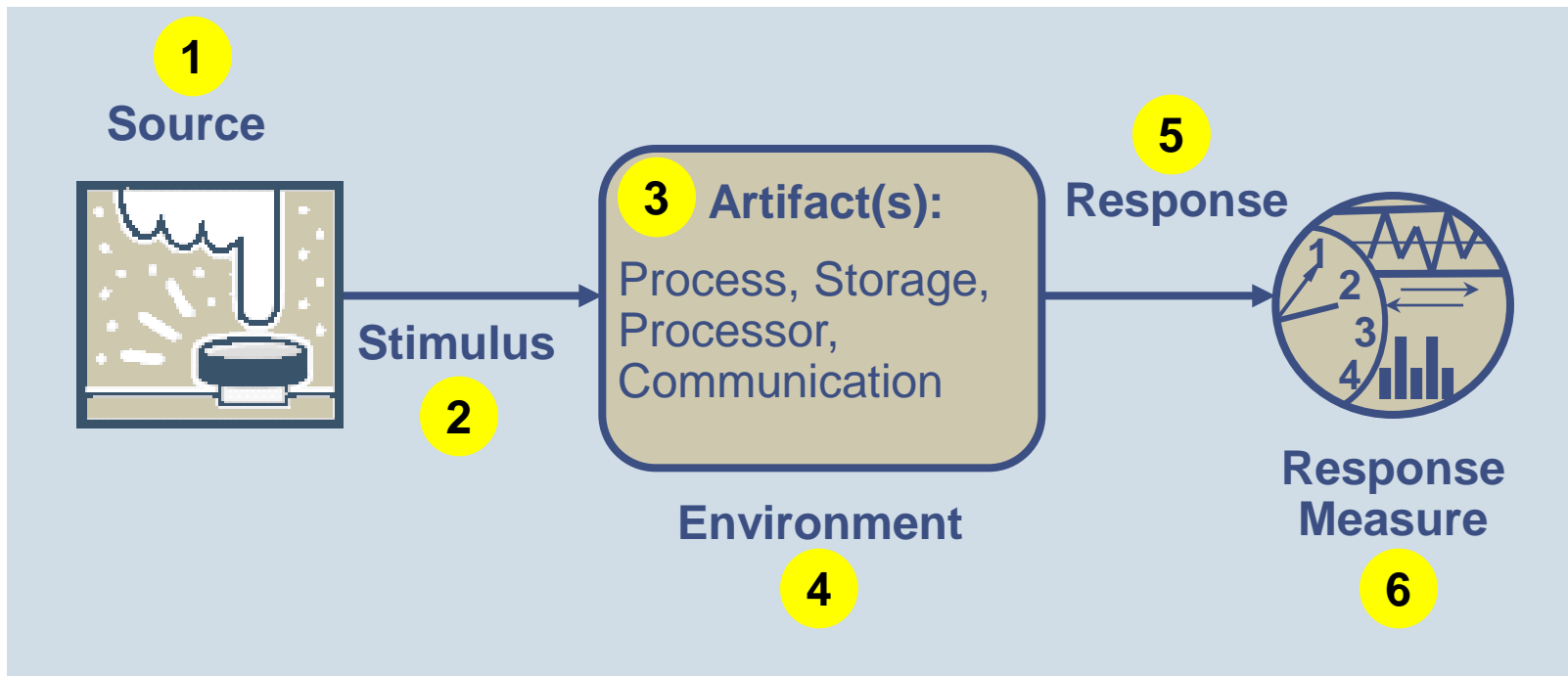
Quality attribute scenarios complement use cases and user stories

- Use cases and user stories focus on functionality – what must the system do
- Scenarios focus on how the system must deliver the functionality
- Stimulus for a scenario can come from the use case or user story





# Quality Attribute Scenarios for Systems and Software



# System of Systems

What distinguishes a a system of systems from other complex assemblages of large-scale components?

- The constituent components are systems *can* operate independently to fulfill customer or operator purposes on their own (“operational independence”)
- The component systems actually *do* operate independently (“managerial independence”)

We see this frequently in an enterprise IT context – systems serve multiple purposes with different stakeholders and drivers

Maier, M. “Architecting principles for systems-of-systems”,  
*Systems Engineering*, **1998**, Vol. 1(4), pp. 267-284



# Taking an SoS perspective provides insights

Maier identifies four design principles that can help us succeed in this challenging environment

- Stable Intermediate Forms – “Complex systems will develop and evolve within an overall architecture much more rapidly if there are stable intermediate forms than if there are not.”
- Policy Triage – “The triage: Let the dying die. Ignore those who will recover on their own. And treat only those who would die without help.”
- Leverage at the interfaces – “The greatest leverage in system architecting is at the interfaces. The greatest dangers are also at the interfaces.”
- Ensuring Cooperation – “If a system requires voluntary collaboration, the mechanism and incentives for that collaboration must be designed in.”

Maier, M. “Architecting principles for systems-of-systems”, *Systems Engineering*, **1998**, Vol. 1(4), pp. 267-284



# Enterprise Architecture (EA)

“Enterprise Architecture is the organizing logic for business processes and IT infrastructure reflecting the integration and standardization requirements of the firm’s operating model...The IT unit typically addresses four levels of architecture below the enterprise architecture:

- business process architecture...
- data or information architecture...
- applications architecture...and
- technology architecture...

The term ***enterprise architecture*** can be confusing because the IT unit in some companies refers to one of these architectures—or the set of all four architectures—as the enterprise architecture.”

Ross, J. W., Weill, P., & Robertson, D. C., *Enterprise Architecture as Strategy*, Harvard Business School Press, 2006. <http://www.architectureasstrategy.com/book/eas/about.htm>

See Klein and Gagliardi, *A Workshop on Analysis and Evaluation of Enterprise Architectures*, Technical Report CMU/SEI-2010-023, November 2010 for other definitions.



# An enterprise architecture includes a system of systems architecture

## Parts of an enterprise architecture

- Information Architecture – Repositories and schemas
- Applications Architecture – Automate business process activities, use Information Architecture Repositories, execute on Technology Architecture platforms
- Technology Architecture – Platforms and networks
- Business Process Architecture – Defines the functions, goals, and constraints for the other three architectures.

Many-to-many relationships between elements of each architecture creates a system of systems context

**We find this a useful perspective to take for analysis and evaluation.**

Klein and Gagliardi, *A Workshop on Analysis and Evaluation of Enterprise Architectures*, Technical Report CMU/SEI-2010-023, November 2010.



# Taking an SoS perspective on enterprise architectures

(Almost) never a greenfield project – need to deal with “as-is”, “to-be”, and the path from here to there

- Remember the principle of “stable intermediate states”

## Socio-technical system

- Humans in the loop
  - Indeterminate response characteristics
  - Different failure and recovery modes
- Allocation tradeoffs – human or machine?
- Runtime and development time systems (Mirroring/Conway’s Law)

## Complex environments

- Many and diverse stakeholder groups
- A single constituent system can play many roles
- Direct and indirect relationships among elements

EA can be as much about policy as it is about structure

- Remember “Triage” and “Ensuring Cooperation”



# An Analysis Tool for Enterprise Architectures – Business Threads

A **Business Thread** describes an end-to-end flow through the enterprise, usually encompassing multiple business processes

Examples:

- “Quote to Cash”
- Shop to Order to Fulfillment to Return
- Symptom/Problem to Primary Care to Hospital Admission to Discharge to Rehab

Inspirations for the concept include Mission Threads (DoD) and “Green Threads” (IBM Rational)

A business thread typically involves

- Multiple actors
- Multiple applications
- Data in multiple repositories
- Often cross organizational boundaries, may include elements “external” to the enterprise



# Categories of Business Threads

## Core Business Threads

- Trace through the core business processes of the enterprise
- Examples on previous slide are “core business” threads
- Splice together “traditional” business processes

## Operations Threads

- Trace through support operations processes
- Examples include deployment, migration, “go-live”, day-to-day management, training, and disaster recovery
- Look for “business processes” in ITIL or Data Center Operations manuals

## Development Threads

- Trace through development, test, and integration
- Use development plans and operating procedures as a starting point





# Business Thread Types

“As-Is” – these threads reflect as-is capabilities that must be maintained as the EA changes, for example during integration of an acquired company.

“To-Be” – these threads reflect well-defined future capabilities that must be supported in a new or evolved architecture.

“What-If” – these threads are analogous to “Growth Scenarios” in the QAW, exploring opportunities and testing the limits of the EA.



# Polling Question #1

## We deal with quality attribute requirements...

- a) Systematically - we collect quality attribute requirements for all areas
- b) Partially - we look at some qualities like performance and security, for some capabilities
- c) Barely - we focus mostly on functional requirements



# Business Thread Workshop (BTW) – Developing EA Quality Attribute Requirements

The BTW *augments EA business threads* with quality attribute considerations that shape the EA architecture and *identifies EA architectural challenges*, as early in the EA development cycle as possible

The business thread augmentation is performed by key EA stakeholders using a structured and facilitated process (extension of the QAW)

The augmented threads and discovered challenges are used to develop the enterprise architecture, and then reused to evaluate the EA

There will usually be a series of BTWs, depending on scope, scale, and schedule considerations



# BTW Inputs

EA Business Drivers Presentation

- Includes quality attributes

EA Architecture Plans Presentation

Business Contexts and Business Threads



# Quality Attribute Augmentation Process

For each business thread:

- Elicit any over-arching quality attribute considerations, e.g. security, interoperability, etc.
- Capture any over-arching assumptions, engineering issues, challenges, etc.
- For each step in the business thread:
  - For each quality attribute, elicit quality attribute considerations. Record any engineering issues, assumptions, challenges, etc.
  - Capture any capability or other issues that arise

Stakeholder inputs are key



# BTW Outputs

## Augmented Business Threads

- Over-arching quality attribute augmentations for the business thread
- Capability and business goal augmentations for the business thread
- Quality attribute augmentations for each event in the business thread
- Identified additional use cases (with context) and business threads

## Challenges

- Architectural, capability, and business challenges derived from the business thread augmentations.
- Any candidate legacy system architecture that may require architecture evaluation.



# Polling Question #2

## We evaluate our architecture...

- a) Systematically - we do it for every project
- b) Partially - we evaluate selected projects  
(based on cost, perceived risk, ...)
- c) Barely - we don't really evaluate our architecture  
before construction



# Perspectives for EA Evaluation

Enterprise architecture is a process

- Evaluate the quality of the process and adherence to the process with methods like CMMI®

The enterprise architecture process is carried out by individuals and teams working within an organization

- Evaluate the competence of the people, teams, and organization using a method like the SEI Architecture Competence Assessment

Business processes are a first-order element in enterprise architecture.

- Use an Organizational Coordination Theory perspective to evaluate alignment between the business processes and organizational structures

“Architecture is Architecture is Architecture” (John Zachman)

- Extend ATAM method to Enterprise Architectures





# Enterprise Architecture Evaluation

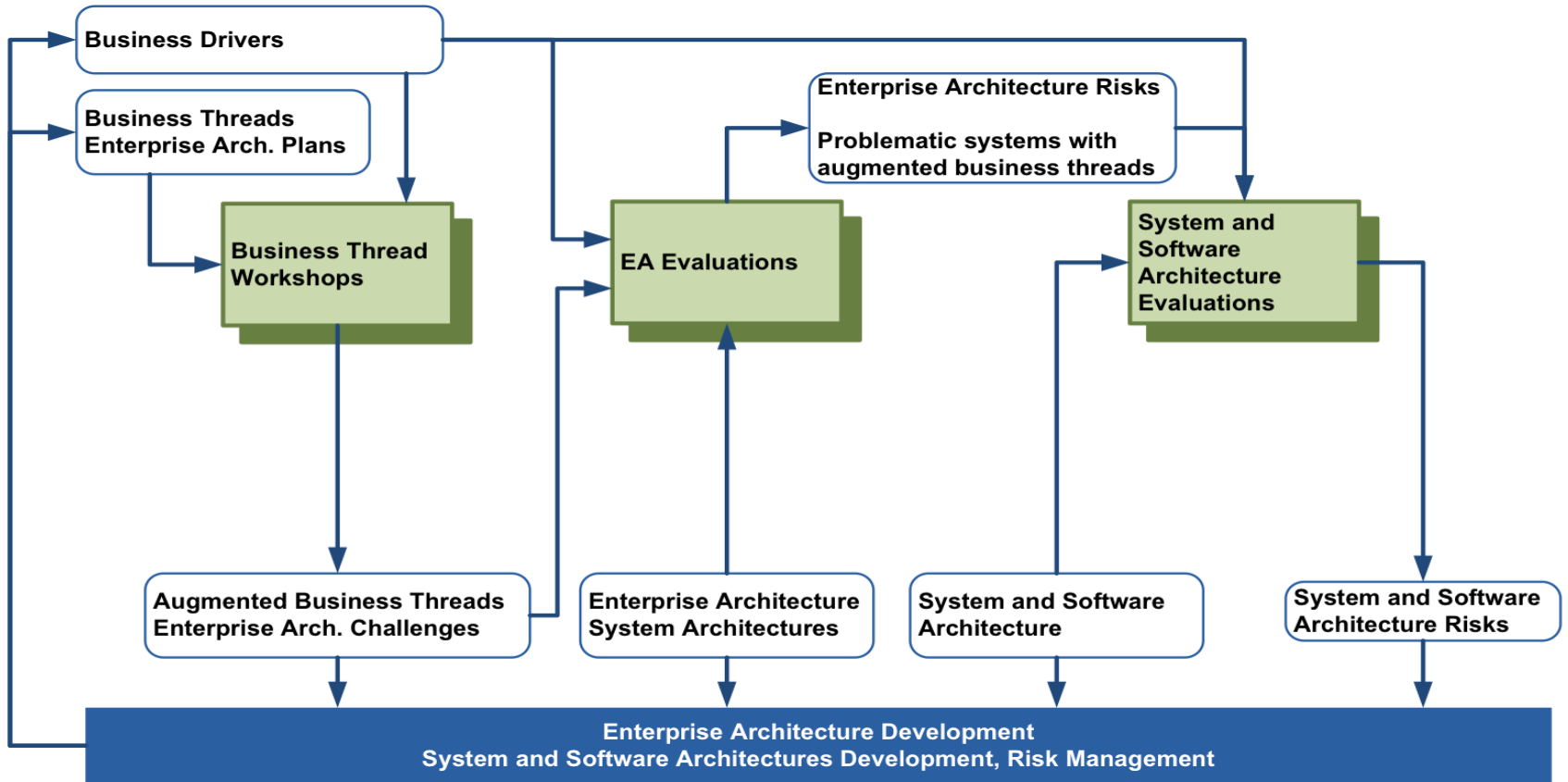
Treat EA as a System of Systems – perform first pass identification of architectural risks and quality attribute inconsistencies across the constituent systems.

Similar approach to ATAM, applied at the EA level

- Instead of scenarios, use augmented mission threads from the BTW
- Pre-select the augmented mission threads for evaluations
- Schedule a series of EA architecture evaluations (1-2 days each)
- Assemble a trained EA evaluation team
- Gather EA and system architecture documentation
- Bring together stakeholders (including EA, system and software architects)
- Architects walk through the architecture, one augmented mission thread at a time, with evaluation team probing for risks, non-risks, etc.
- Risks are rolled up into risk themes
- Identify problematic areas for more focused system/software architecture evaluations, if necessary

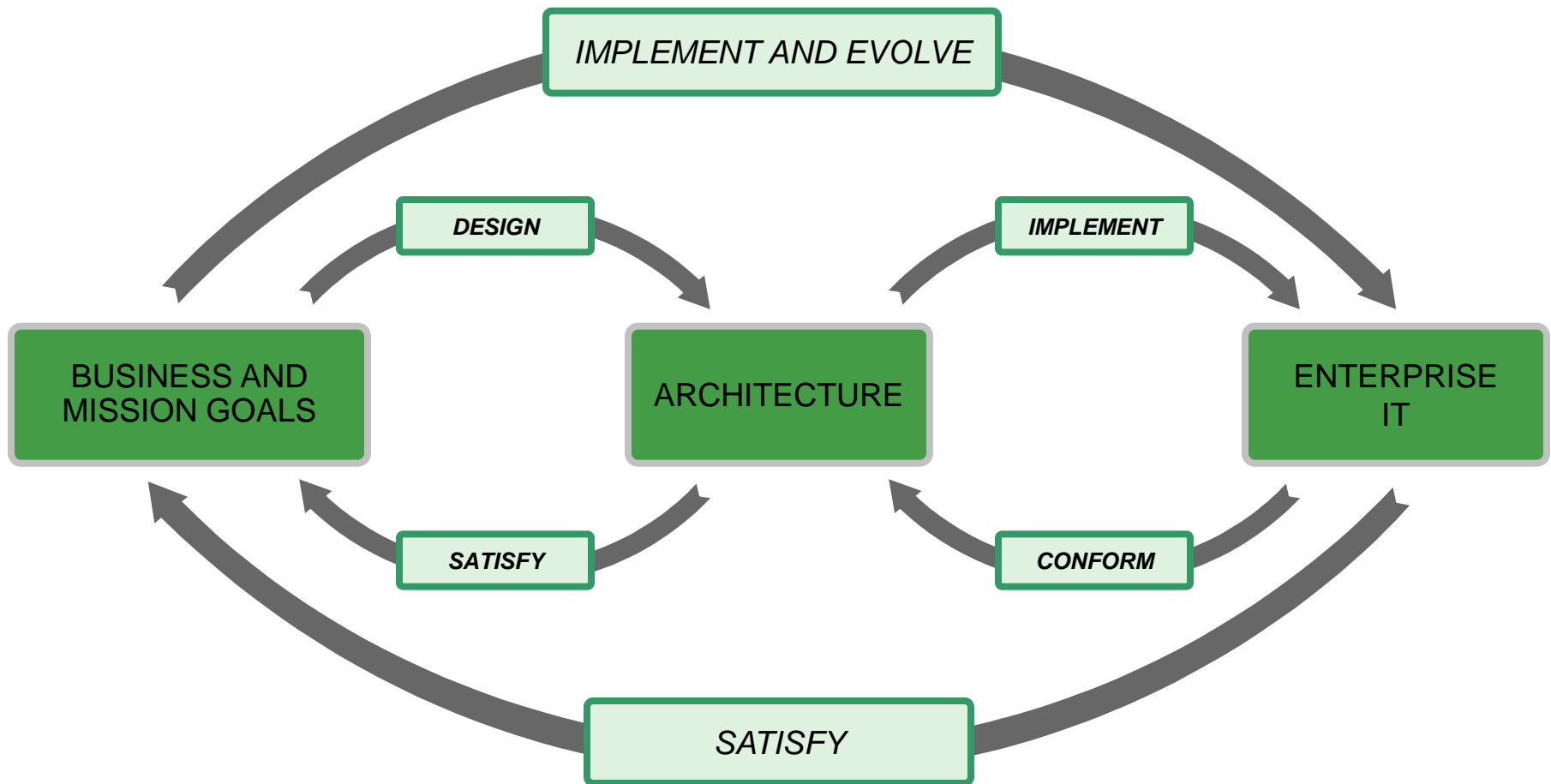


# Enterprise Architecture – Uniform Approach



Gagliardi, M., Wood, W. G., Klein, J., & Morley, J. (2009, March/April). A Uniform Approach for System of Systems Architecture Evaluation. *CrossTalk*, 12-15.

# Architecture-centric Engineering – Enterprise IT Architecture



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<http://www.sei.cmu.edu/architecture/people/>

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# Q&A

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